Universidad Popular del Cesar

Reconocimiento de Patrones

Version 2022-2

HoG - Human Detection

[Capítulo 2]

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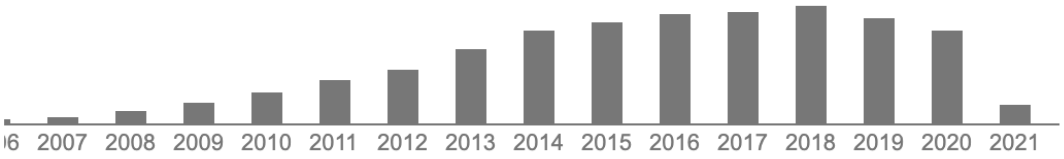
HoG: Histogram of oriented gradients

Navneet Dalal

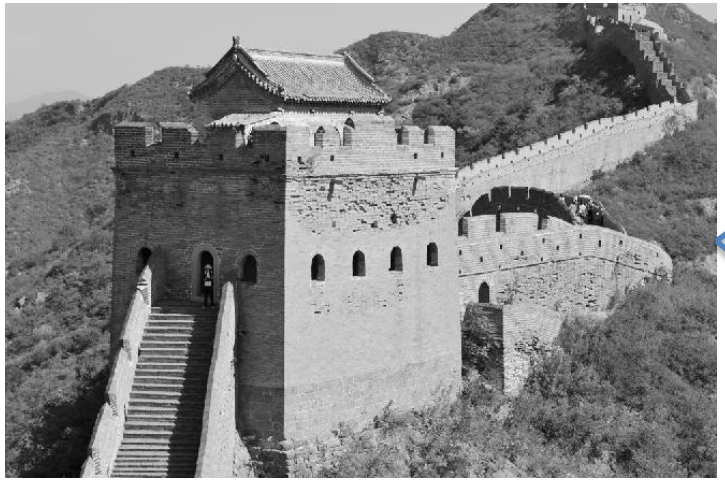
Histograms of oriented gradients for human detection

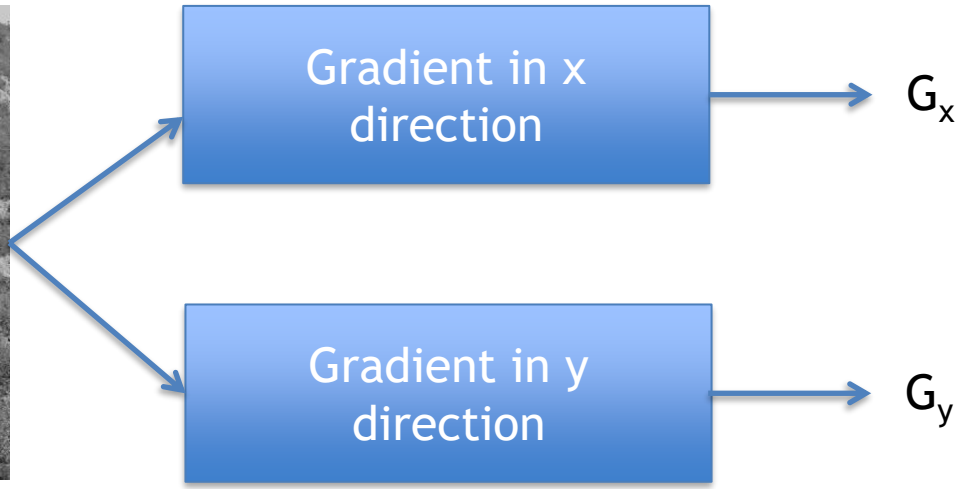
Authors	Navneet Dalal, Bill Triggs
Publication date	2005/6/20
Conference	2005 IEEE computer society conference on computer vision and pattern recognition (CVPR'05)
Volume	1
Pages	886-893
Publisher	Ieee
Description	We study the question of feature sets for robust visual object recognition; adopting linear SVM based human detection as a test case. After reviewing existing edge and gradient based descriptors, we show experimentally that grids of histograms of oriented gradient (HOG) descriptors significantly outperform existing feature sets for human detection. We study the influence of each stage of the computation on performance, concluding that fine-scale gradients, fine orientation binning, relatively coarse spatial binning, and high-quality local contrast normalization in overlapping descriptor blocks are all important for good results. The new approach gives near-perfect separation on the original MIT pedestrian database, so we introduce a more challenging dataset containing over 1800 annotated human images with a large range of pose variations and backgrounds.
Total citations	Cited by 35511



N Dalal, B Triggs: Histograms of oriented gradients for human detection. Computer Vision and Pattern Recognition, (CVPR 2005).

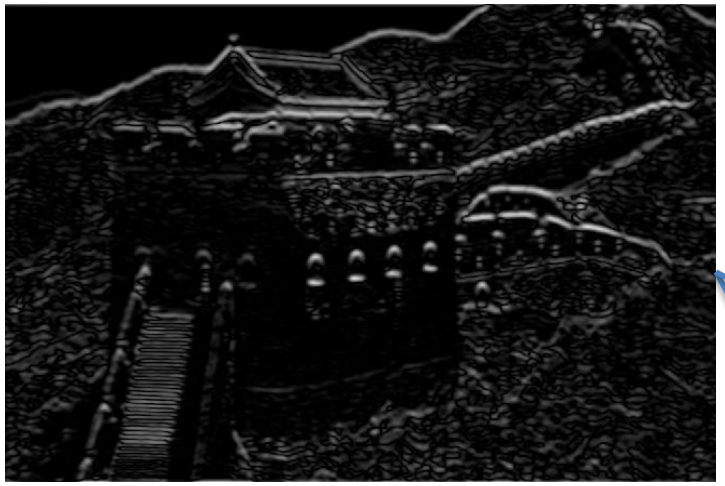
Histogram of Gradients



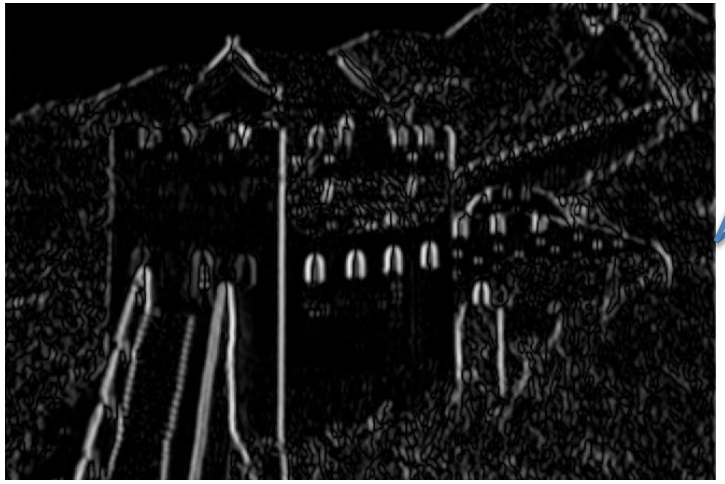


Histogram of Gradients

G_x: Gradient in x direction



G_y: Gradient in y direction



Magnitude → R

$= \text{sqrt}(G_x^2+G_y^2)$

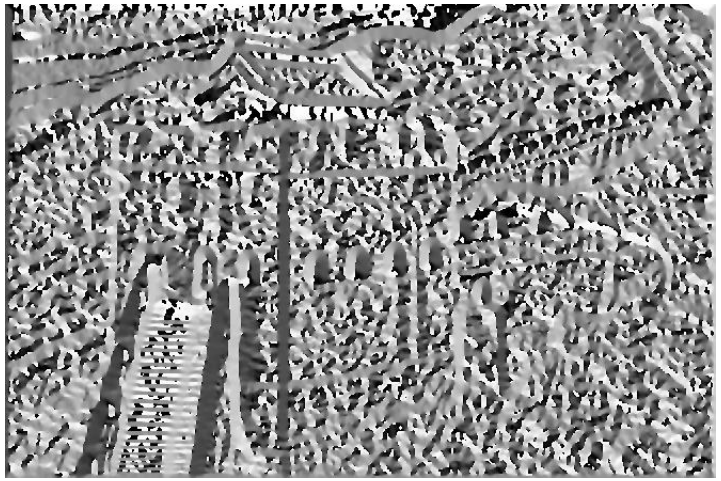
Angle → A

$= \arctan(Gy/G_x)$

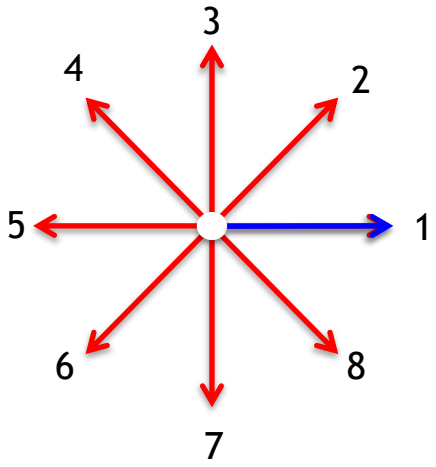
Histogram of Gradients

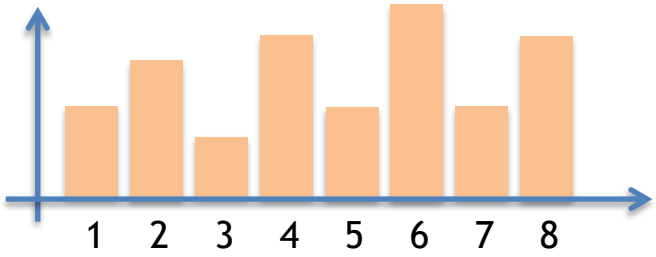
R: Magnitude

A: Angle



Histogram of 8 directions

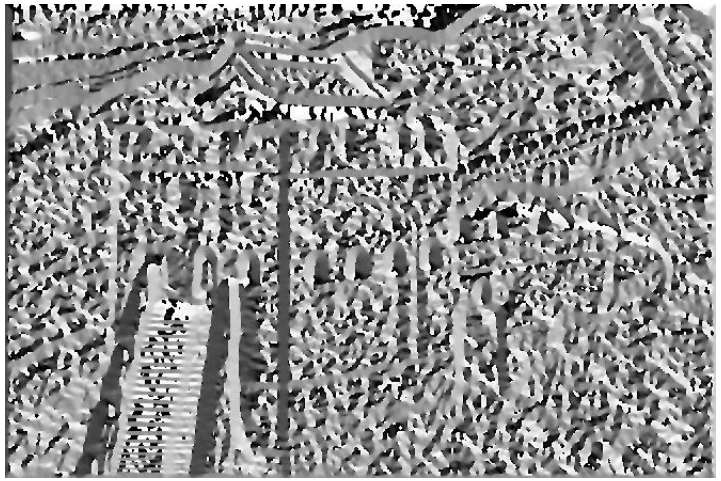




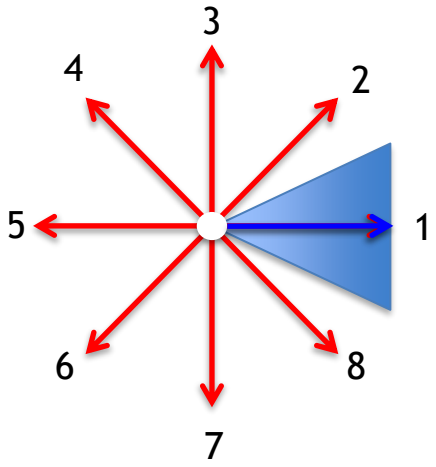
Histogram of Gradients

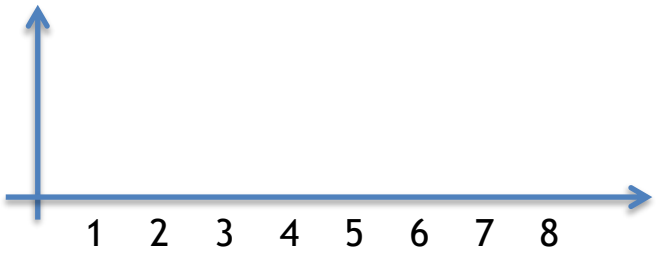
R: Magnitude

A: Angle



Histogram of 8 directions
(computation of first bin)

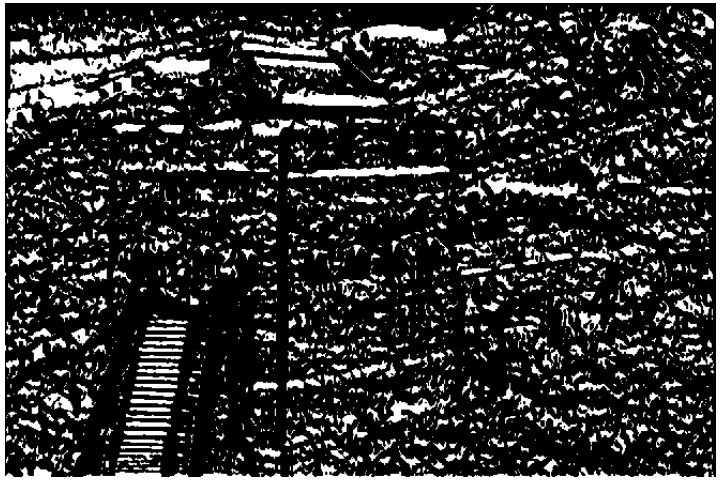




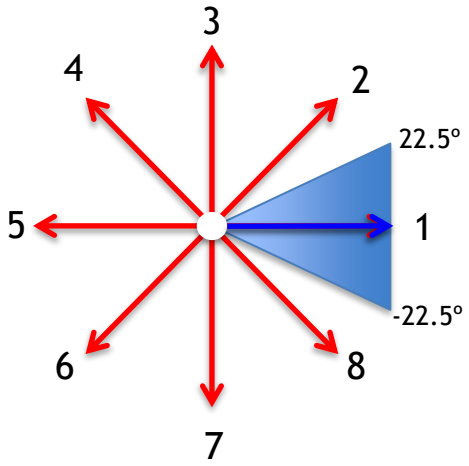
Histogram of Gradients

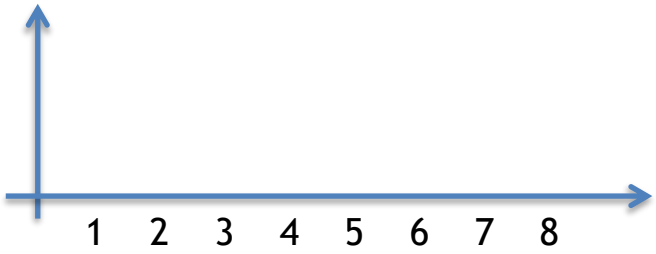
R: Magnitude

A: Angle between -22.5° and 22.5°



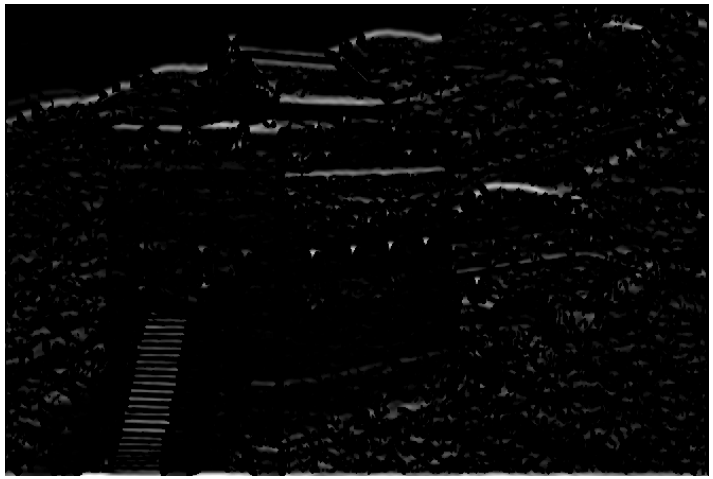
Histogram of 8 directions
(computation of first bin)



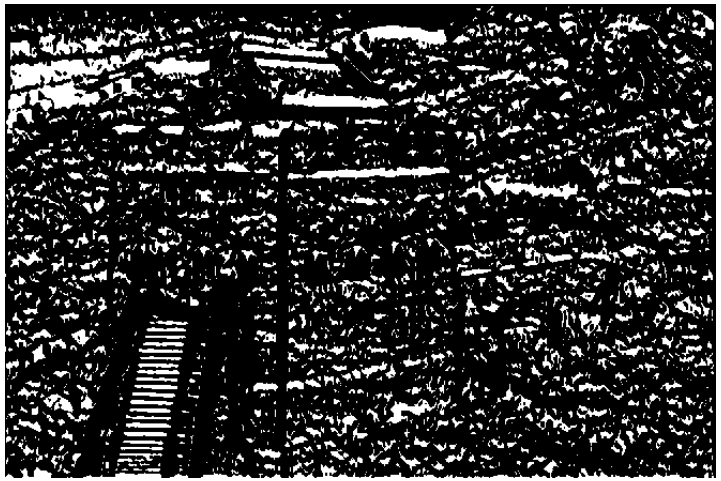


Histogram of Gradients

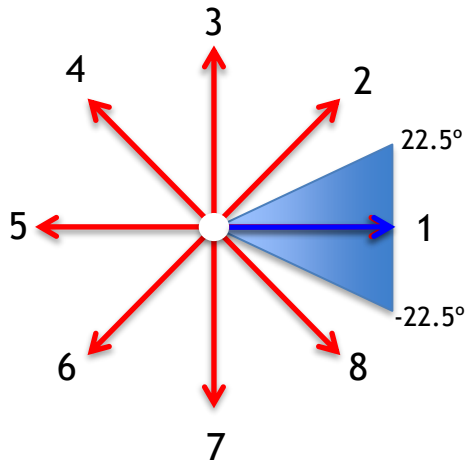
R: Magnitude in this direction



A: Angle between -22.5° and 22.5°



Histogram of 8 directions
(computation of first bin)



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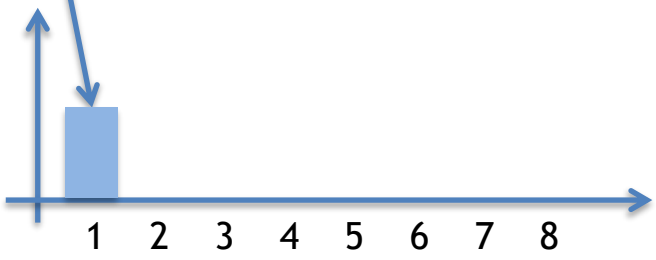
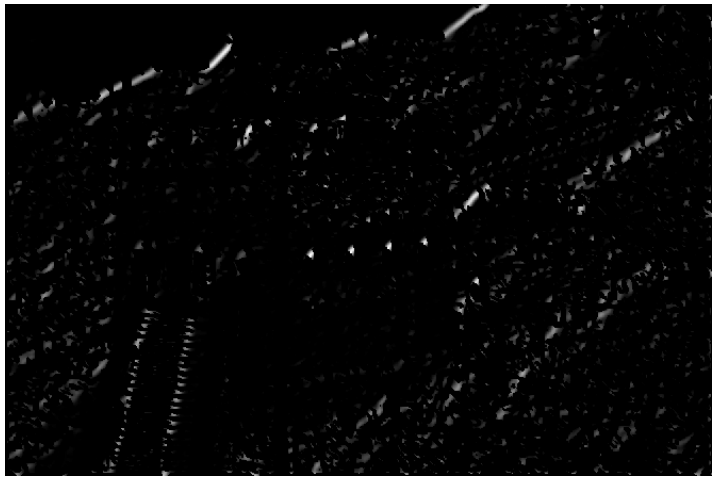


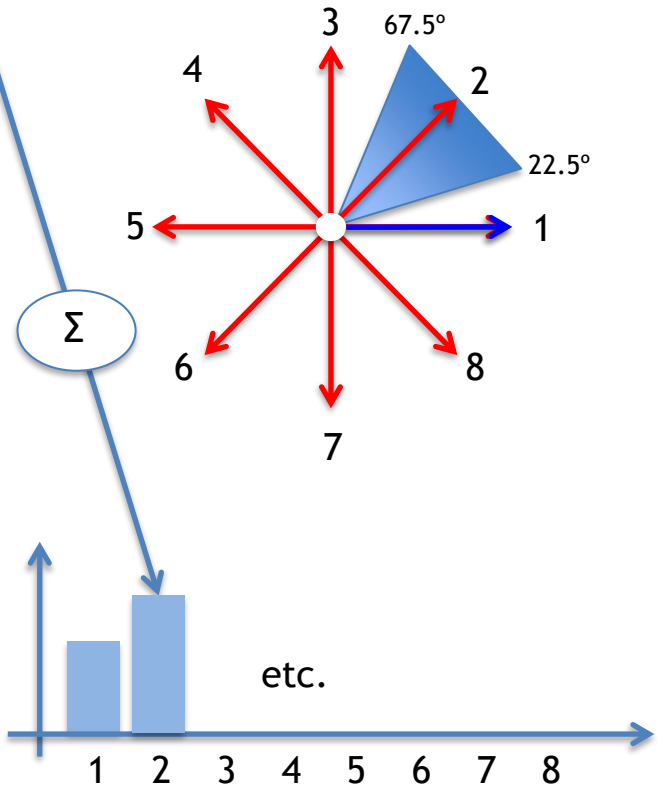
Histogram of Gradients

R: Magnitude in this direction



A: Angle between 22.5° and 67.5°

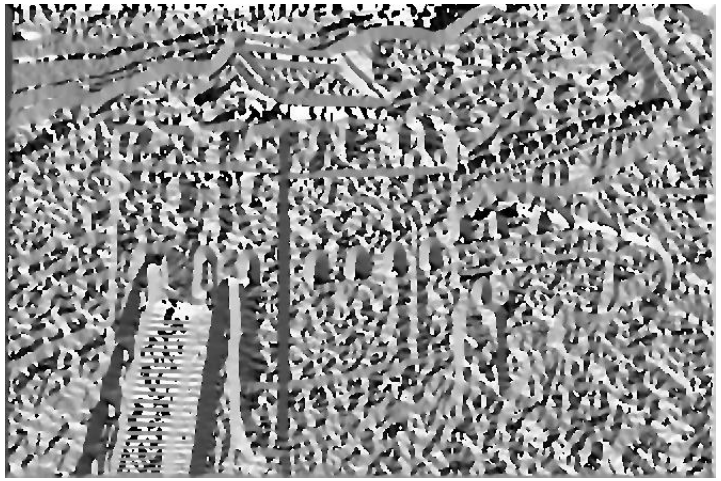
Histogram of 8 directions
(computation of second bin)



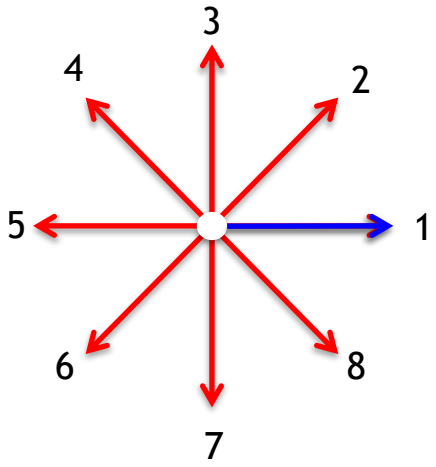
Histogram of Gradients

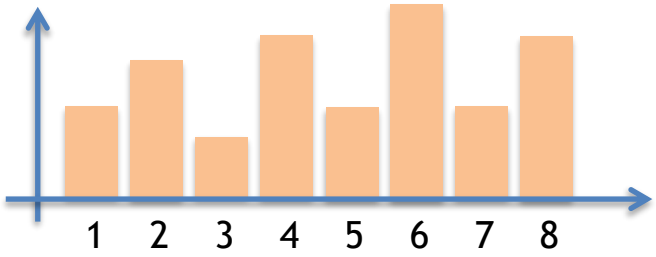
R: Magnitude

A: Angle



Histogram of 8 directions

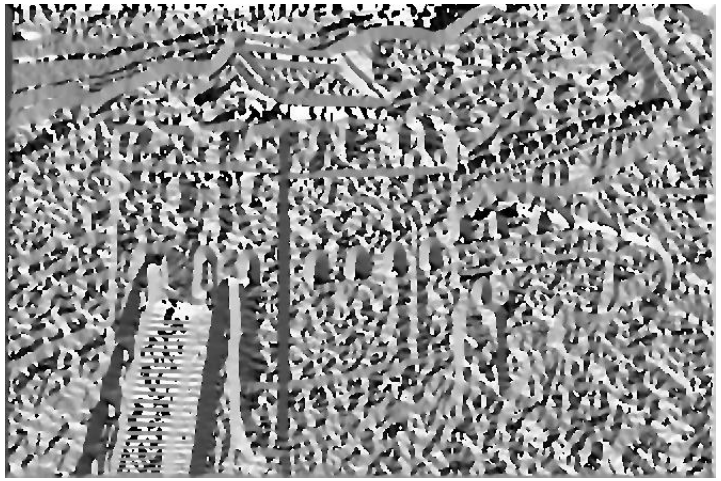




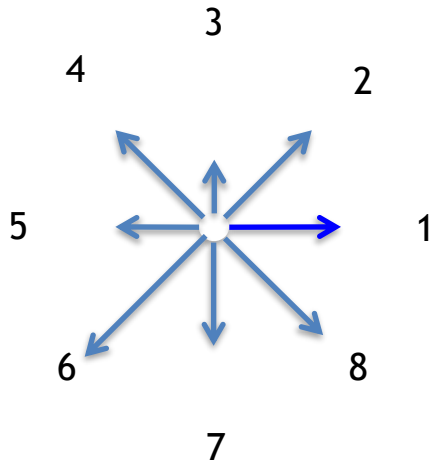
Histogram of Gradients

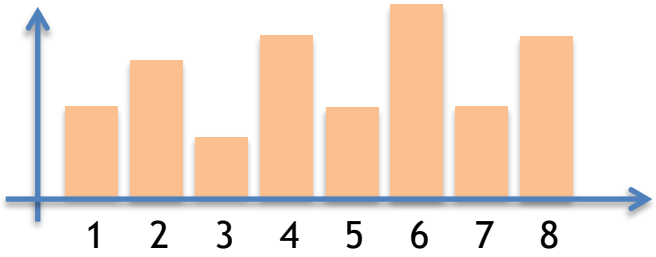
R: Magnitude

A: Angle

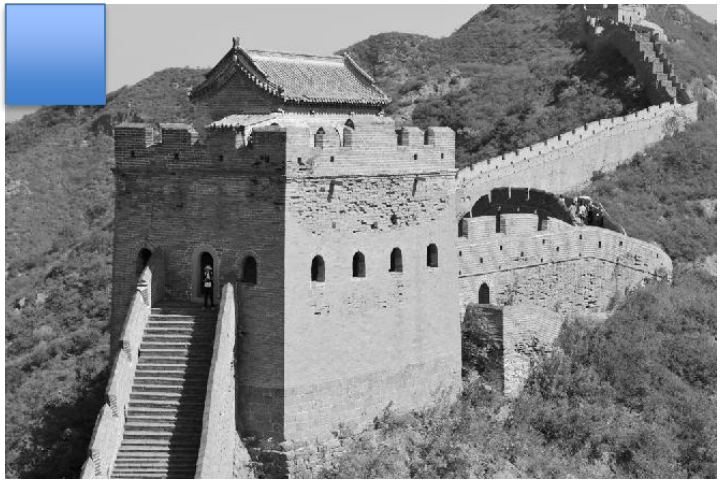


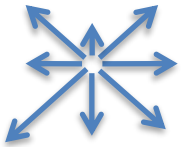
Histogram of 8 directions

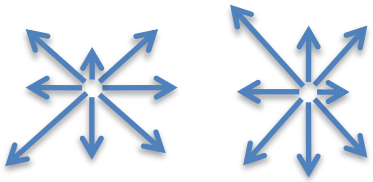


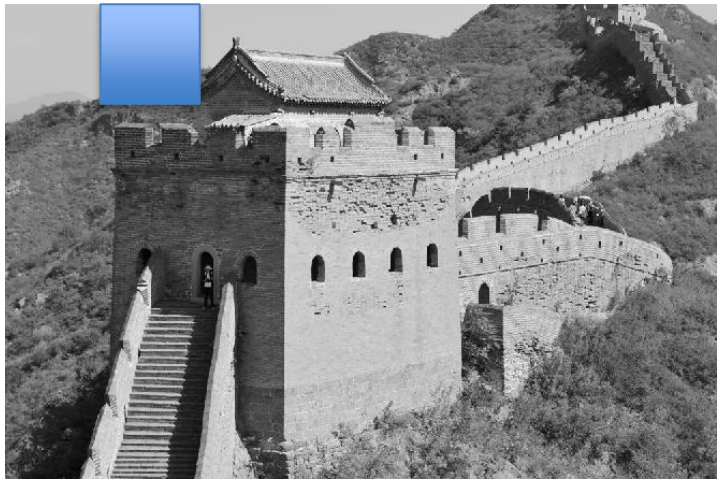


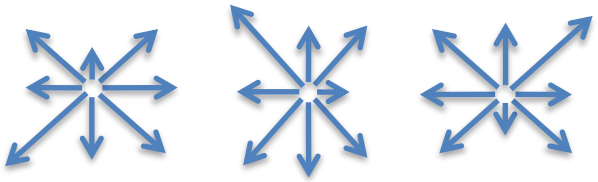
The descriptor proposed by the authors is a concatenation of HoG in different overlapped partitions

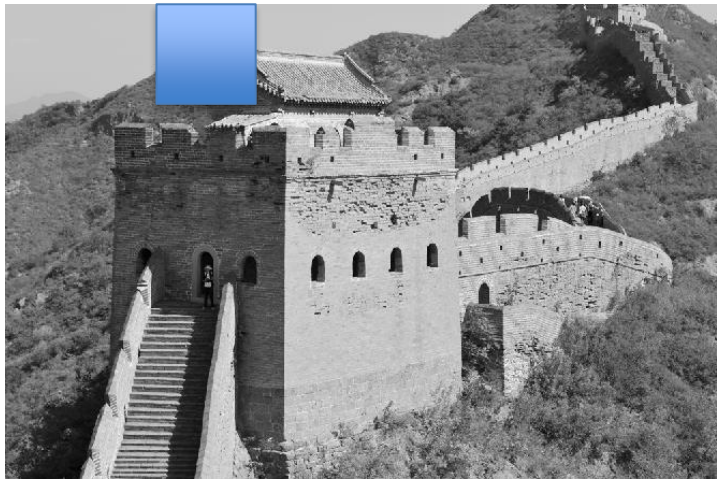


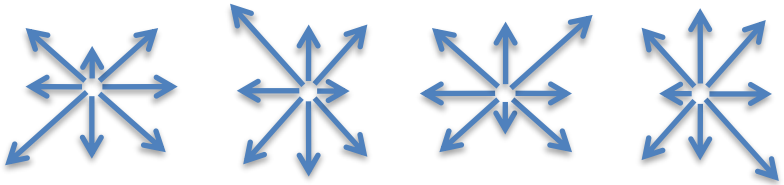


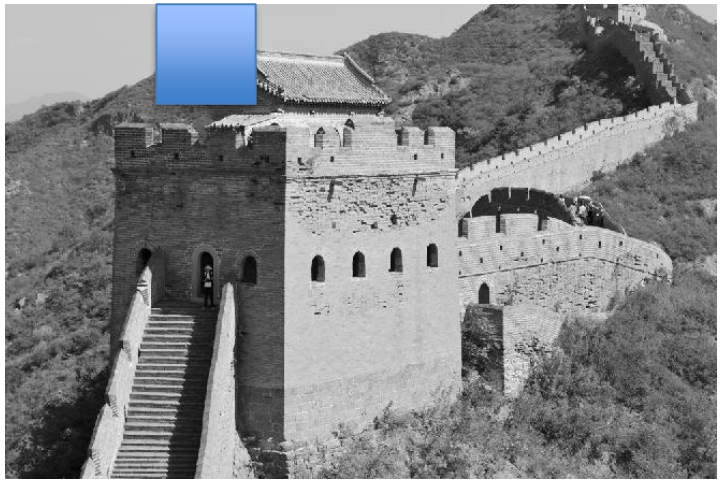


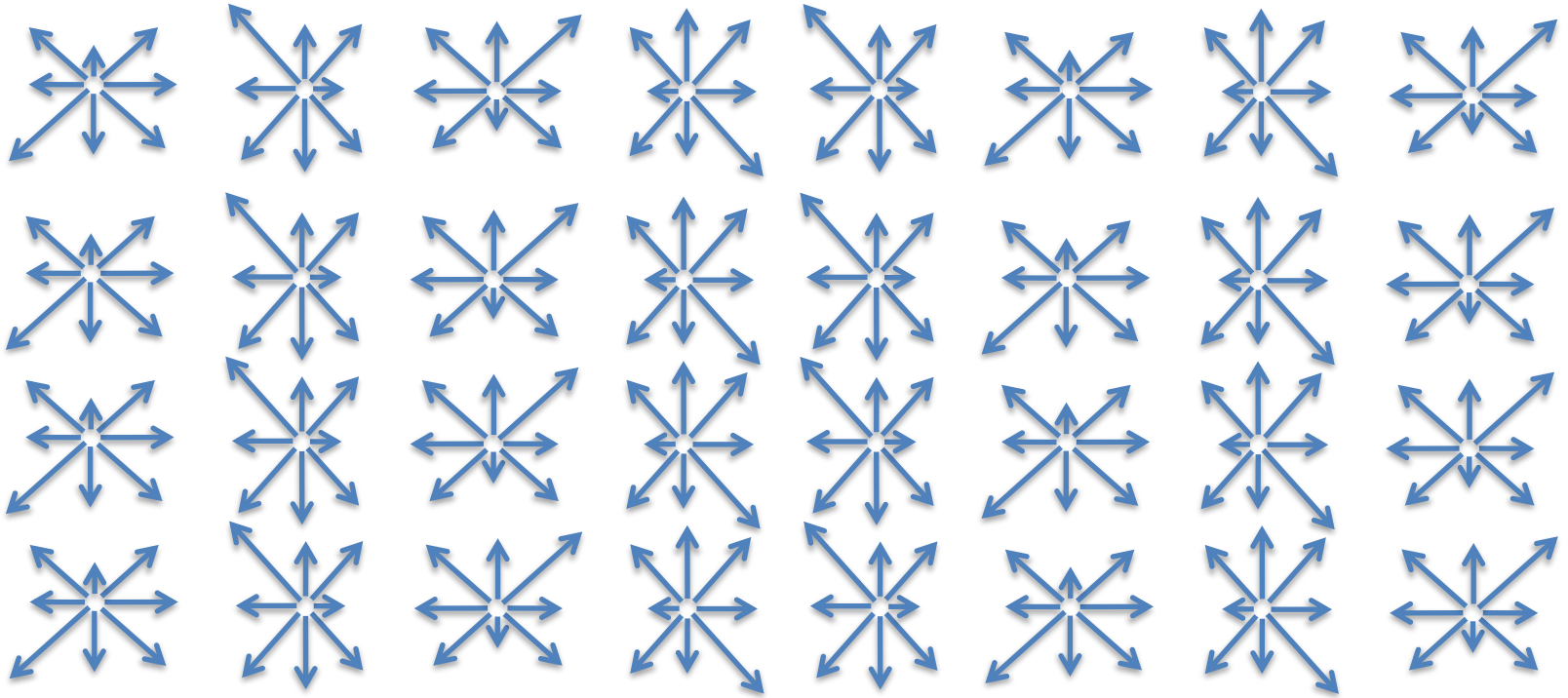


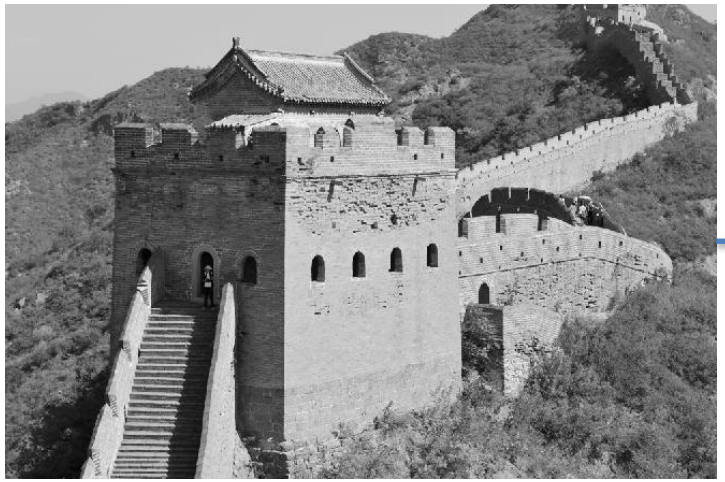




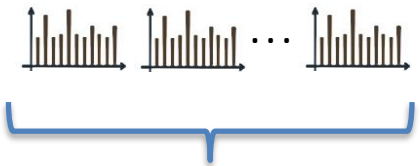






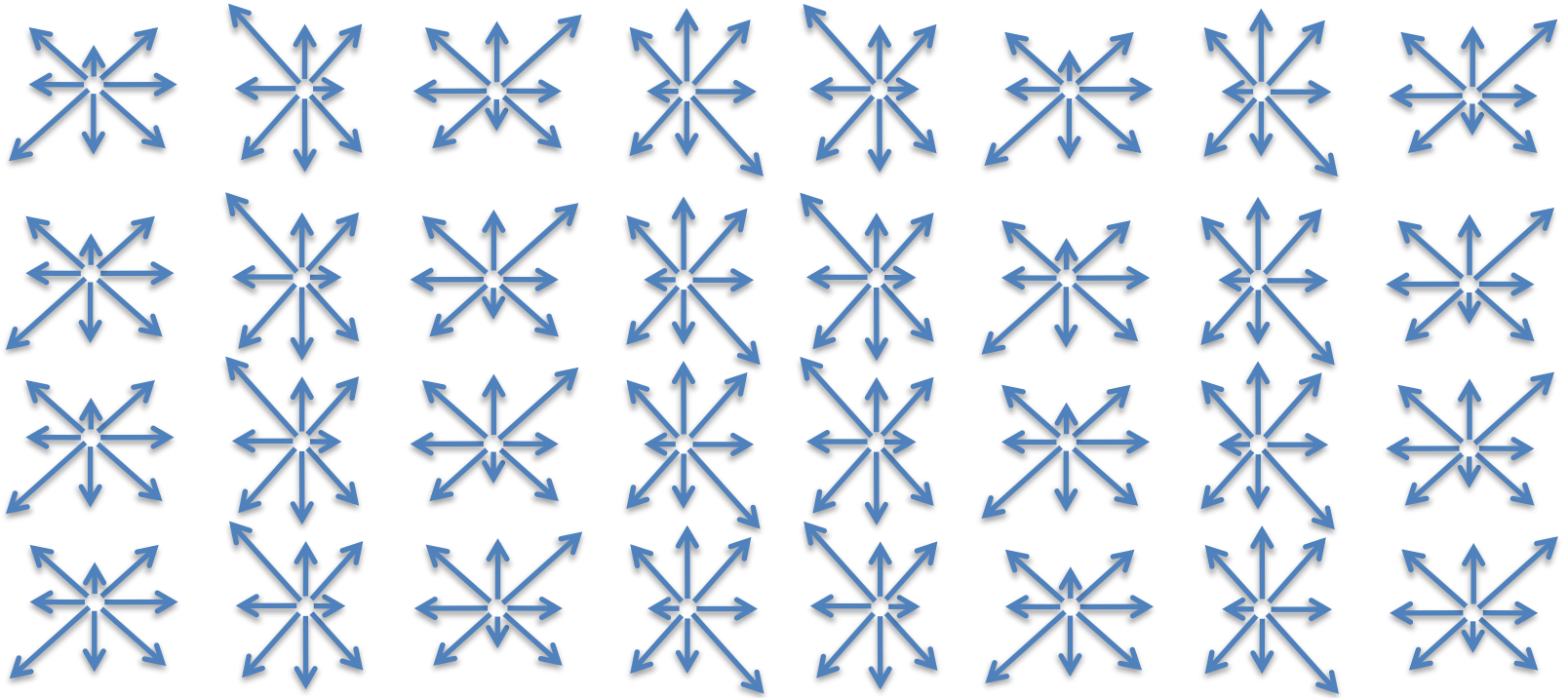


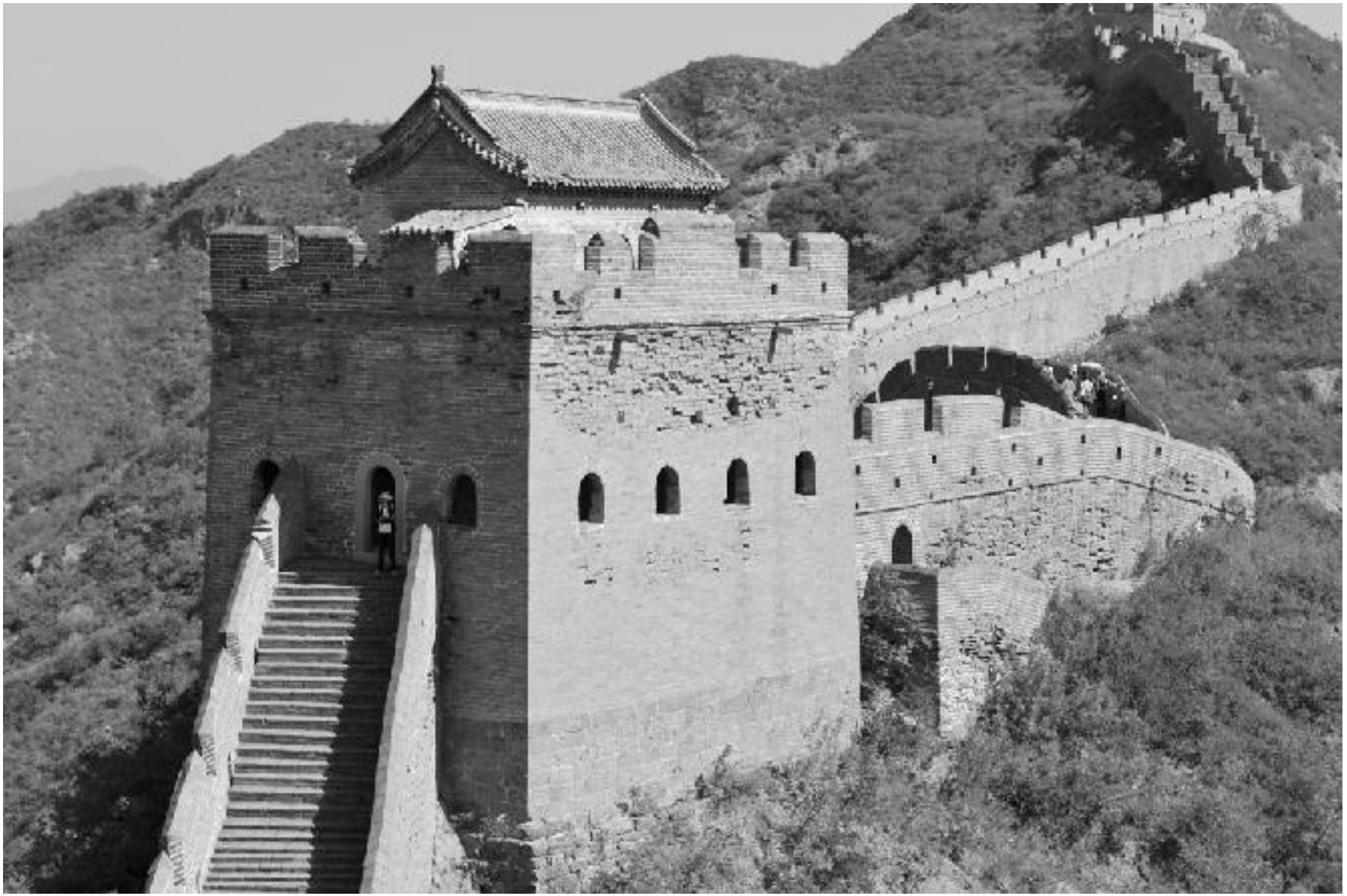
Feature Extraction

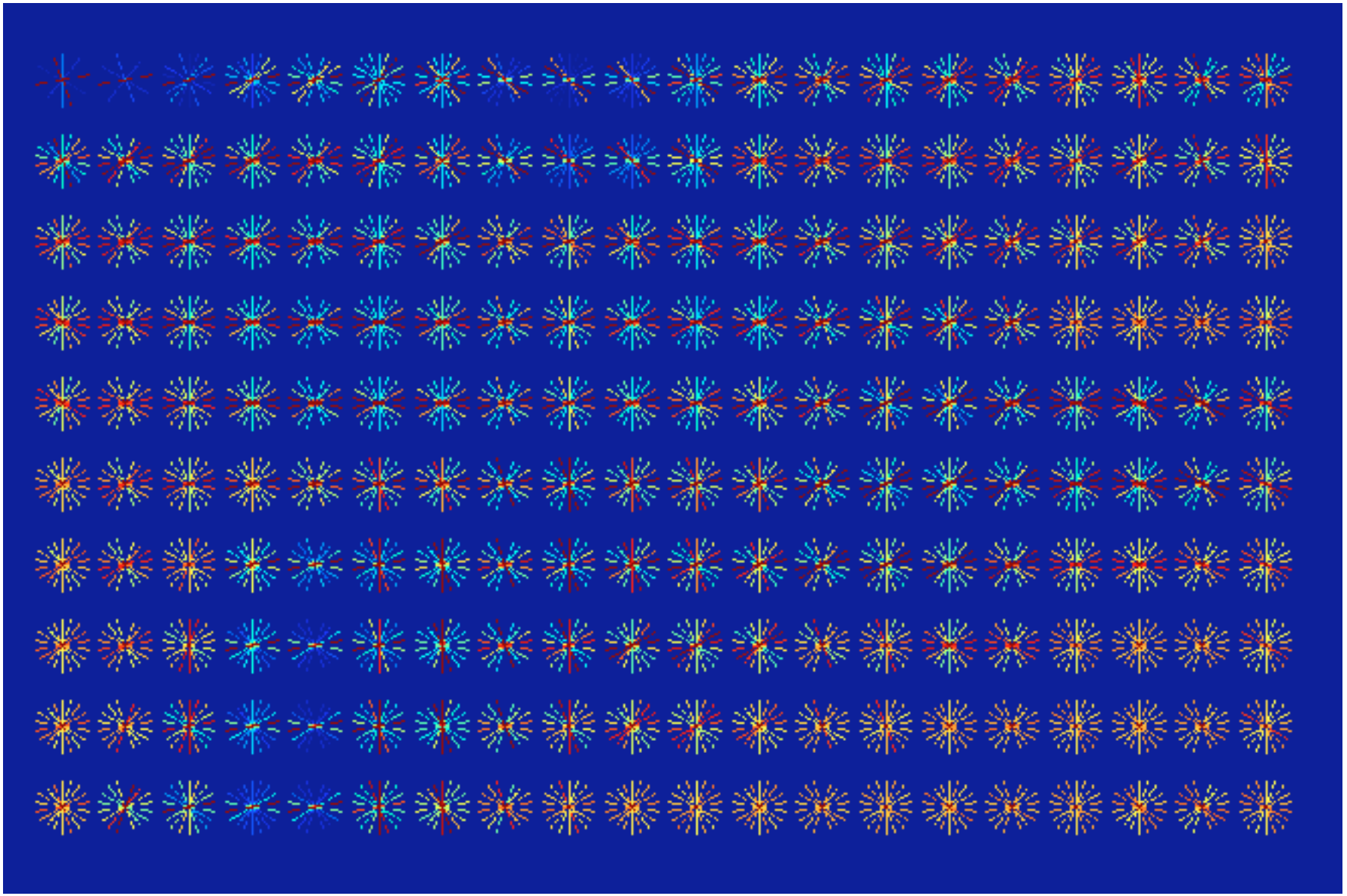


Descriptor of n elements

n = # cells x # bins



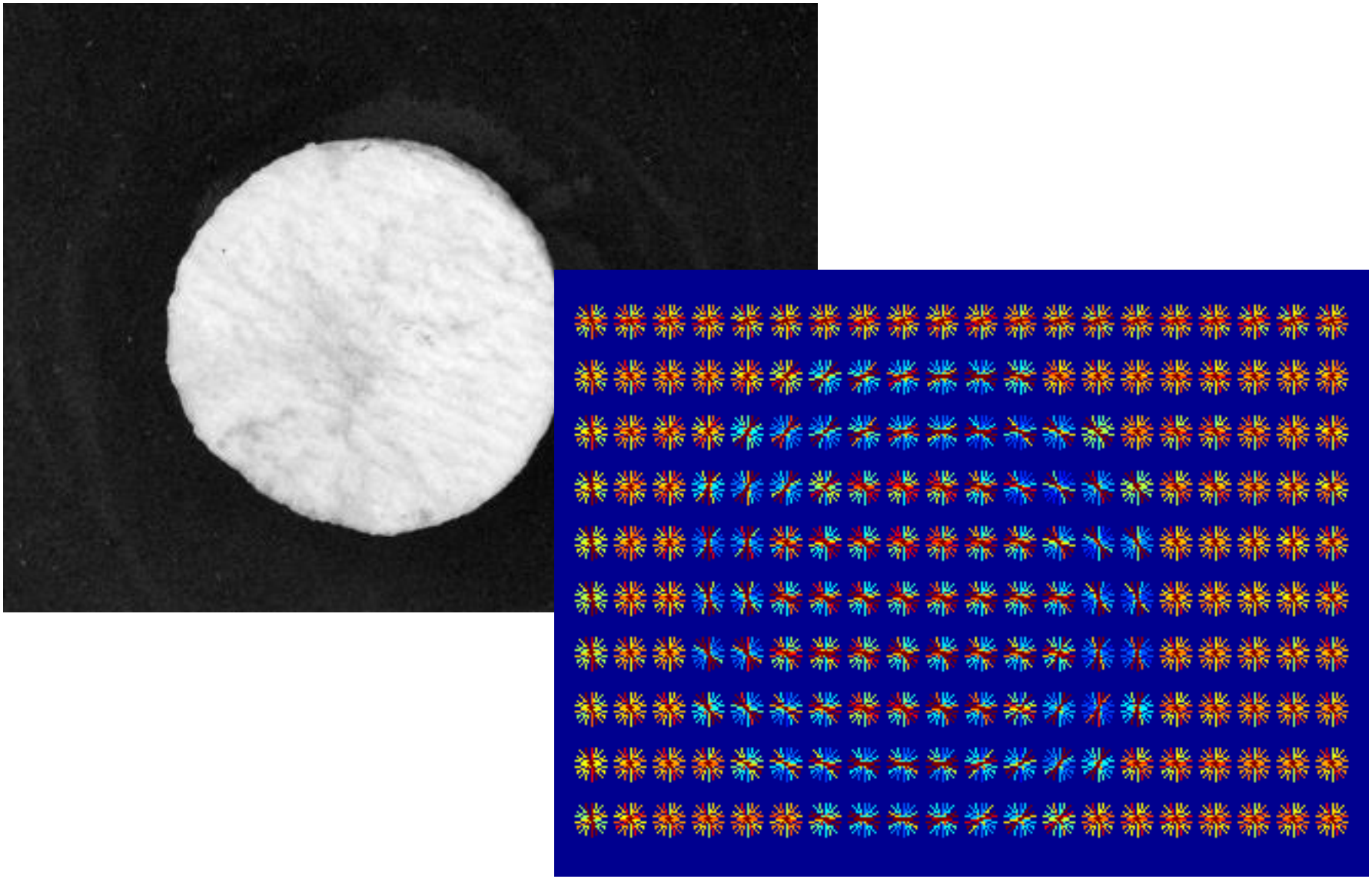




Example using Balu Library in Matlab:

```
options.nj    = 20;                 % 10 x 20
options.ni    = 10;                 % histograms
options.B     = 9;                  % 9 bins
options.show  = 1;                  % show results
I = imread('testimg1.jpg');         % input image
J = rgb2gray(I);
figure(1);imshow(J,[]);
figure(2);
[X,Xn] = Bfx_hog(J,options);        % HOG features (see gradients
                                    % arround perimeter).
```

Example using Balu:



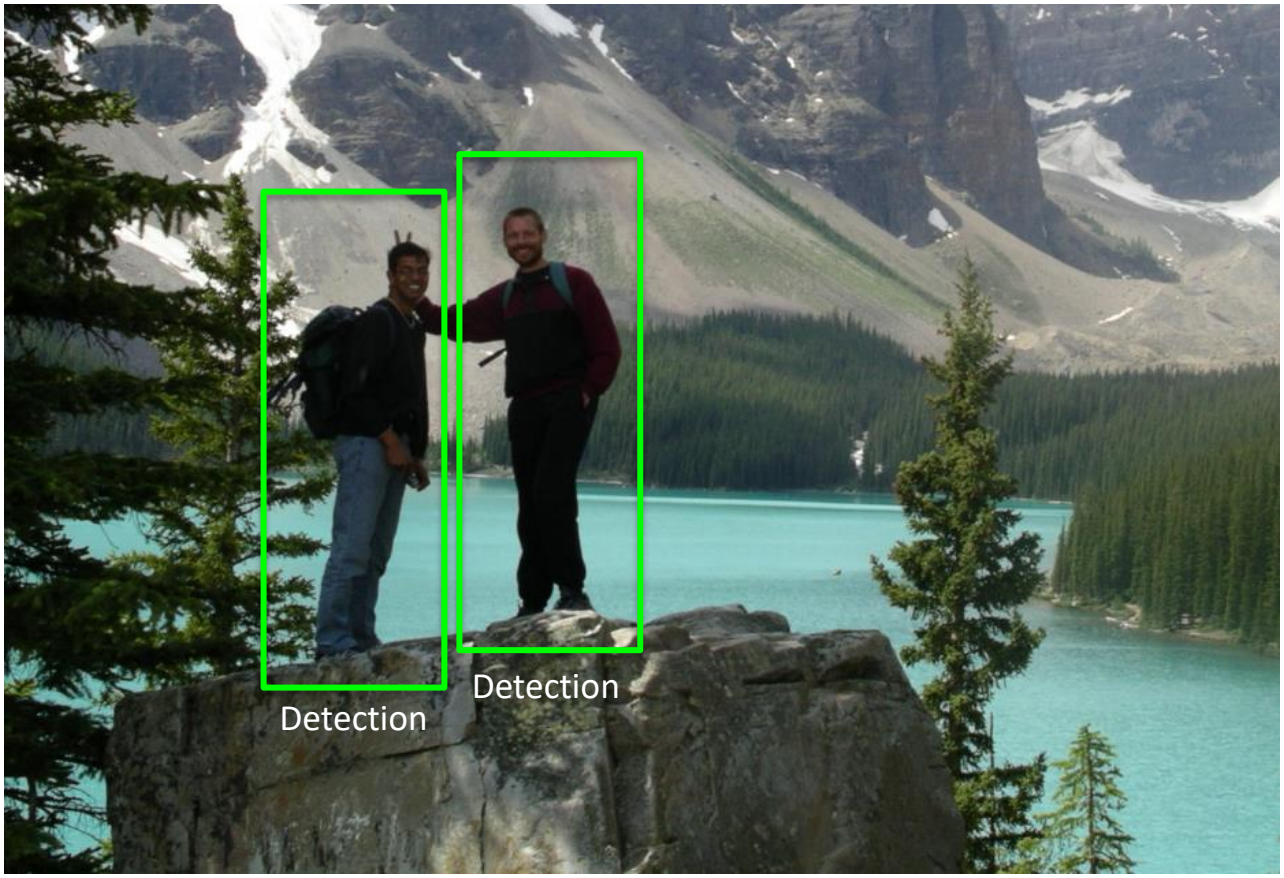
How to detect pedestrians using HoG?

The Solution

Strategy: Sliding Windows

Strategy: Sliding Windows

Strategy: Sliding Windows



The Key-Idea:

Design a classifier that is able to distinguish between pedestrians from no-pedestrians.

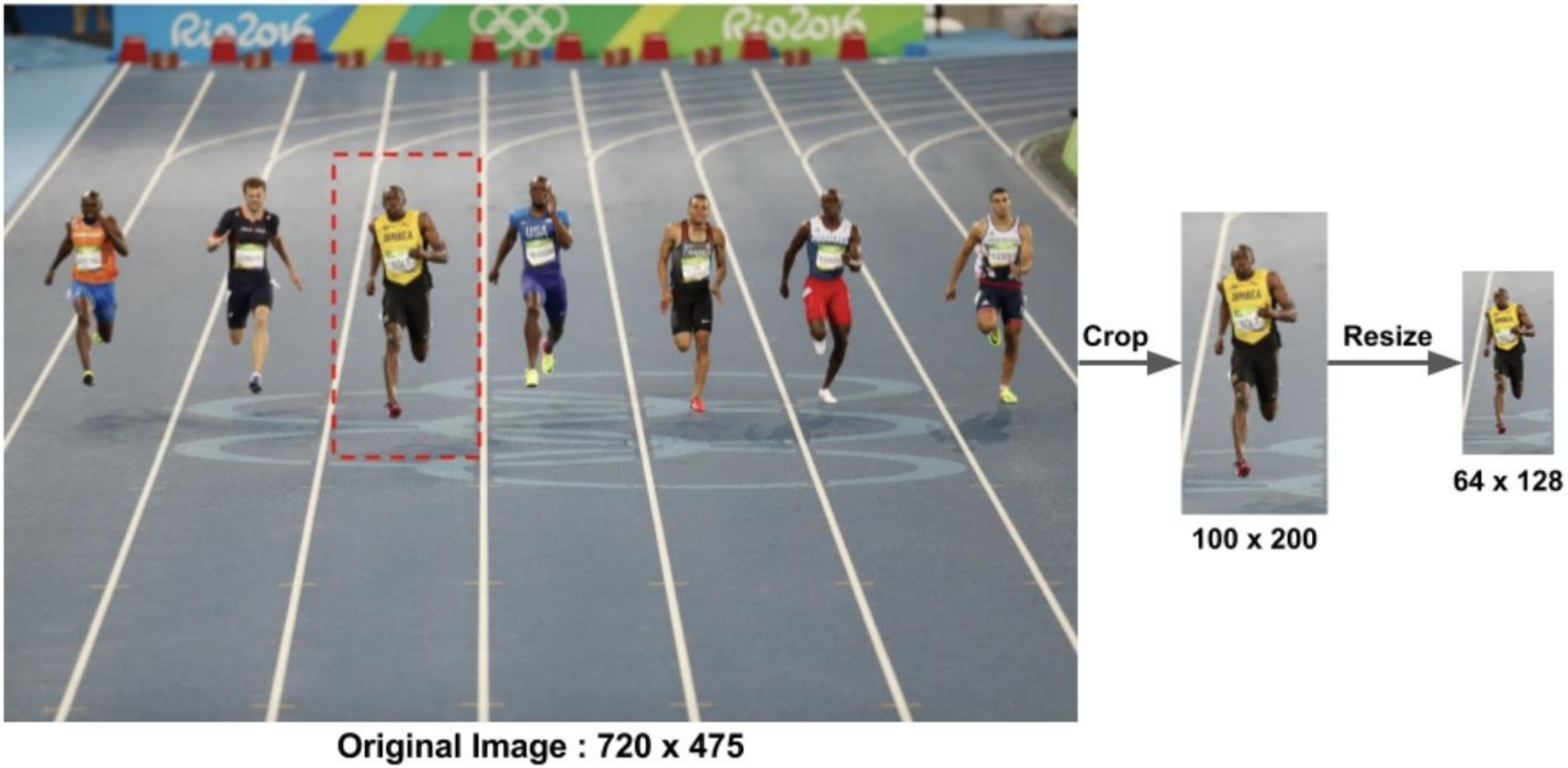
Positive Class: Pedestrians

Pedestrian

Negative Class: No-Pedestrians

No-Pedestrian

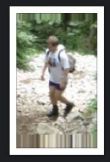
Construction of the Dataset: Positive Class



Positive Class: Pedestrians


crop_000010a.png


crop_000010b.png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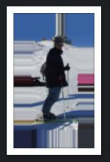
crop_000011b.png


crop_000603a.png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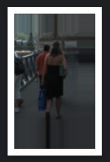
crop_000606a.png


crop_000606b.png


crop_000606c.png


crop_000606d.png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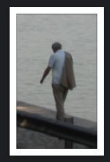
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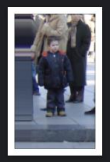
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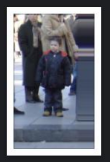
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crop001003a.png


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crop001003c.png


crop001003d.png


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crop001004b.png


crop001004c.png


crop001004d.png


crop001005c.png


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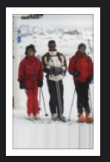
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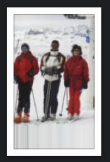
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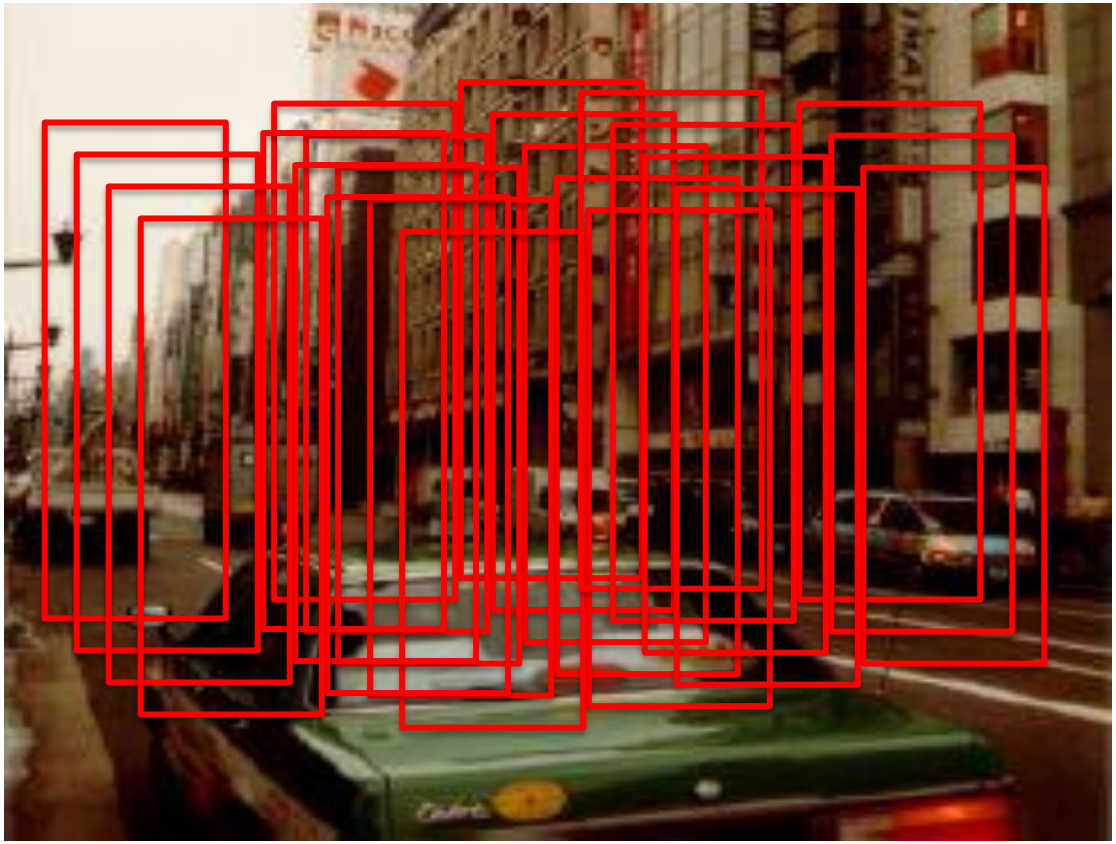
Construction of the Dataset: Negative Class

Construction of the Dataset: Negative Class



Negative Class: No-Pedestrians

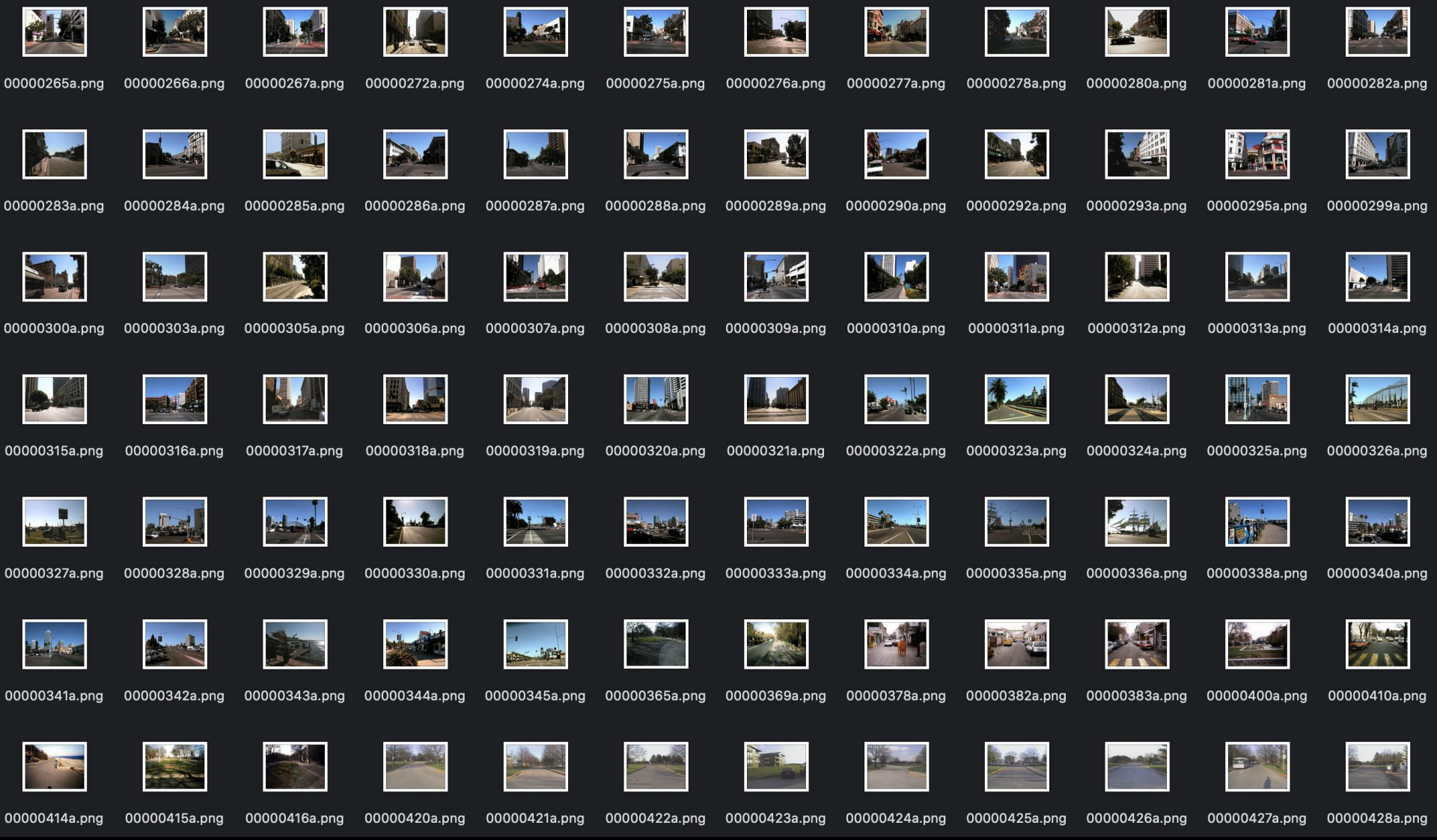
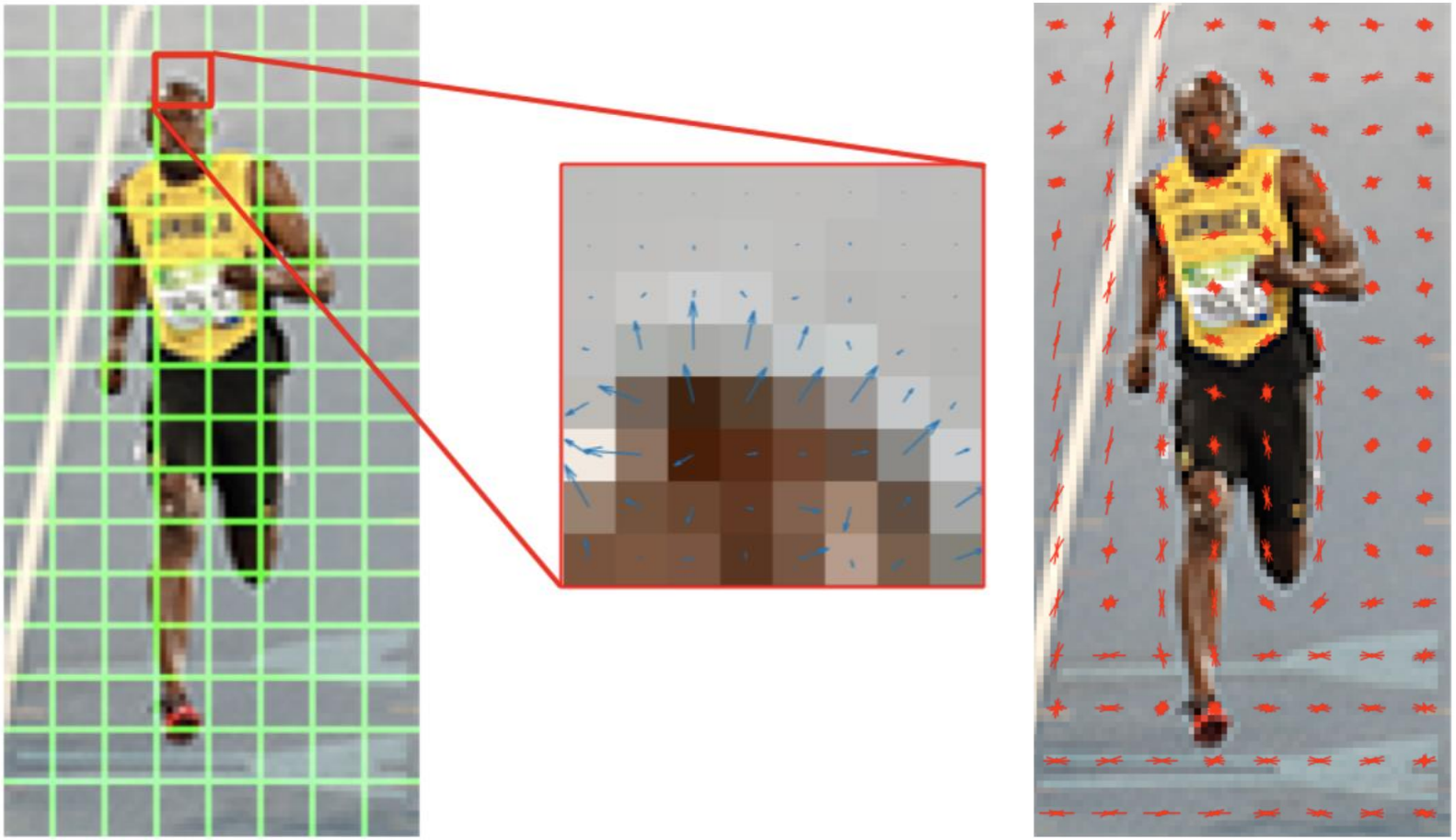


Image:
128 x 64 x 3 pixels

Feature Extraction

Descriptor
3780 elements



Center : The RGB patch and gradients represented using arrows. Right : The gradients in the same patch represented as numbers

https://www.learnopencv.com/histogram-of-oriented-gradients/

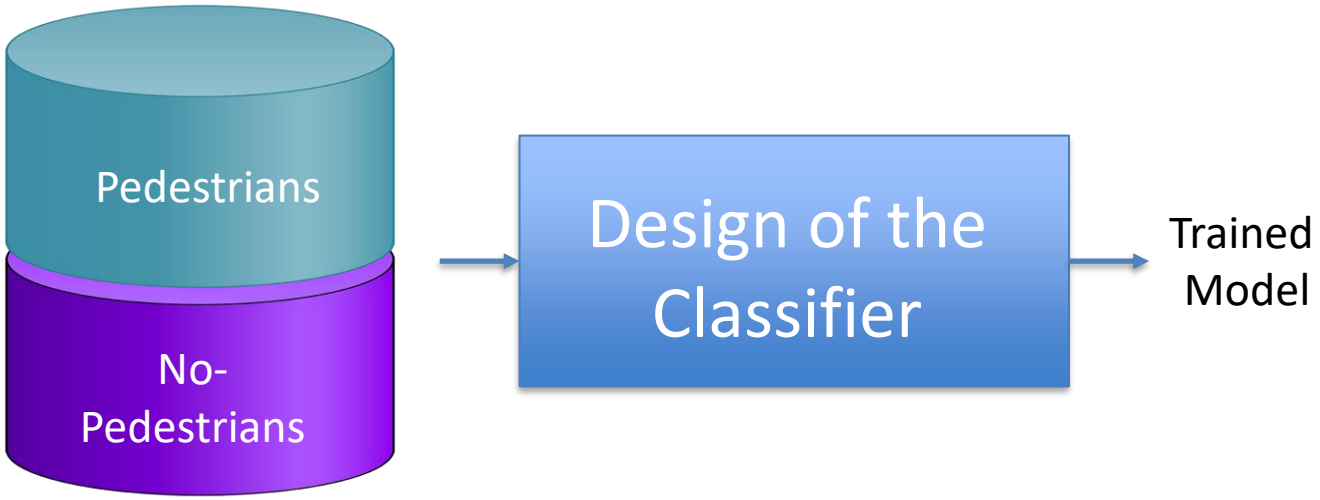
Dataset: Positive Class

Pedestrian	Element-1	Element-2	Element-3	Element-4	Element-5	. . .	Element-3780
1	0.3452	0.1151	0.2685	0.1342	0.2416		0.2301
2	0.2301	0.1534	0.2148	0.1611	0.2071		0.3068
3	0.1726	0.1918	0.1790	0.1879	0.1812		0.3836
4	0.1381	0.2301	0.1534	0.2148	0.1611		0.4603
5	0.1151	0.2685	0.1342	0.2416	0.1450		0.5370
6	0.0986	0.3068	0.1193	0.2685	0.1318		0.6137
7	0.0863	0.3452	0.1074	0.2953	0.1208		0.6904
8	0.0767	0.3836	0.0976	0.3222	0.1115		0.7671
9	0.0690	0.4219	0.0895	0.3490	0.1036		0.8438
10	0.0628	0.4603	0.0826	0.3759	0.0967		0.9205
11	0.0575	0.4986	0.0767	0.4027	0.0906		0.9972
12	0.0531	0.5370	0.0716	0.4296	0.0853		1.0740
13	0.0493	0.5753	0.0671	0.4564	0.0805		1.1507
14	0.0460	0.6137	0.0632	0.4833	0.0763		1.2274
15	0.0432	0.6520	0.0597	0.5101	0.0725		1.3041
16	0.0406	0.6904	0.0565	0.5370	0.0690		1.3808
17	0.0384	0.7288	0.0537	0.5638	0.0659		1.4575
18	0.0363	0.7671	0.0511	0.5907	0.0630		1.5342
19	0.0345	0.8055	0.0488	0.6175	0.0604		1.6109
20	0.0329	0.8438	0.0467	0.6444	0.0580		1.6876
21	0.0314	0.8822	0.0447	0.6712	0.4851		1.7644
22	0.0300	0.9205	0.0430	0.0802	0.6444		1.8411
23	0.0288	0.9589	0.3593	0.0604	0.4660		1.9178
24	0.0276	0.1146	0.4773	0.0835	0.3625		0.2293
25	0.2310	0.0863	0.3452	0.1074	0.2953		0.1726
:	:	:	:	:	:		:
:	:	:	:	:	:		:
100000	0.1230	0.0493	0.5753	0.0671	0.4564		0.0986

Dataset: Negative Class

No-Pedestrian	Element-1	Element-2	Element-3	Element-4	Element-5	. . .	Element-3780
1	0.7452	0.2484	0.5796	0.2898	0.5216		0.4968
2	0.4968	0.3312	0.4637	0.3478	0.4471		0.6624
3	0.3726	0.4140	0.3864	0.4057	0.3912		0.8280
4	0.2981	0.4968	0.3312	0.4637	0.3478		0.9936
5	0.2484	0.5796	0.2898	0.5216	0.3130		1.1592
6	0.2129	0.6624	0.2576	0.5796	0.2845		1.3248
7	0.1863	0.7452	0.2318	0.6376	0.2608		1.4904
8	0.1656	0.8280	0.2108	0.6955	0.2408		1.6560
9	0.1490	0.9108	0.1932	0.7535	0.2236		1.8216
10	0.1355	0.9936	0.1783	0.8114	0.2087		1.9872
11	0.1242	1.0764	0.1656	0.8694	0.1956		2.1528
12	0.1146	1.1592	0.1546	0.9274	0.1841		2.3184
13	0.1065	1.2420	0.1449	0.9853	0.1739		2.4840
14	0.0994	1.3248	0.1364	1.0433	0.1647		2.6496
15	0.0932	1.4076	0.1288	1.1012	0.1565		2.8152
16	0.0877	1.4904	0.1220	1.1592	0.1490		2.9808
17	0.0828	1.5732	0.1159	1.2172	0.1423		3.1464
18	0.0784	1.6560	0.1104	1.2751	0.1361		3.3120
19	0.0745	1.7388	0.1054	1.3331	0.1304		3.4776
20	0.0710	1.8216	0.1008	1.3910	0.1252		3.6432
21	0.0677	1.9044	0.0966	1.4490	0.4851		3.8088
22	0.0648	1.9872	0.0927	0.3740	1.3910		3.9744
23	0.0621	2.0700	0.3593	0.1304	1.0060		4.1400
24	0.0596	0.5342	1.0304	0.1803	0.7825		1.0684
25	0.2310	0.1863	0.7452	0.2318	0.6376		0.3726
:	:	:	:	:	:		:
:	:	:	:	:	:		:
800000	0.9230	0.1065	1.2420	0.1449	0.9853		0.2129

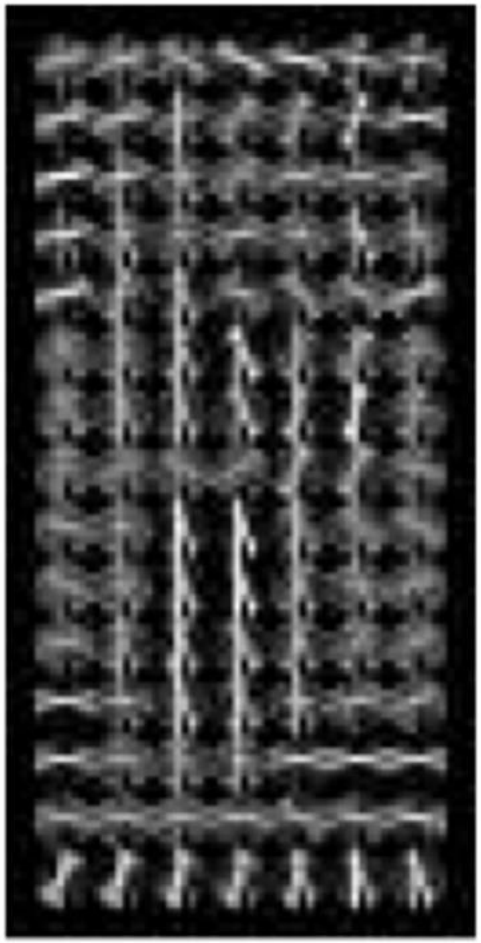
Training



Dataset

Image:
128 x 64 x 3 pixels

Descriptor
3780 elements



Output:
0 / 1

Pedestrian

Feature Extraction
Using HoG Features

Classification
Using Trained Model


Example

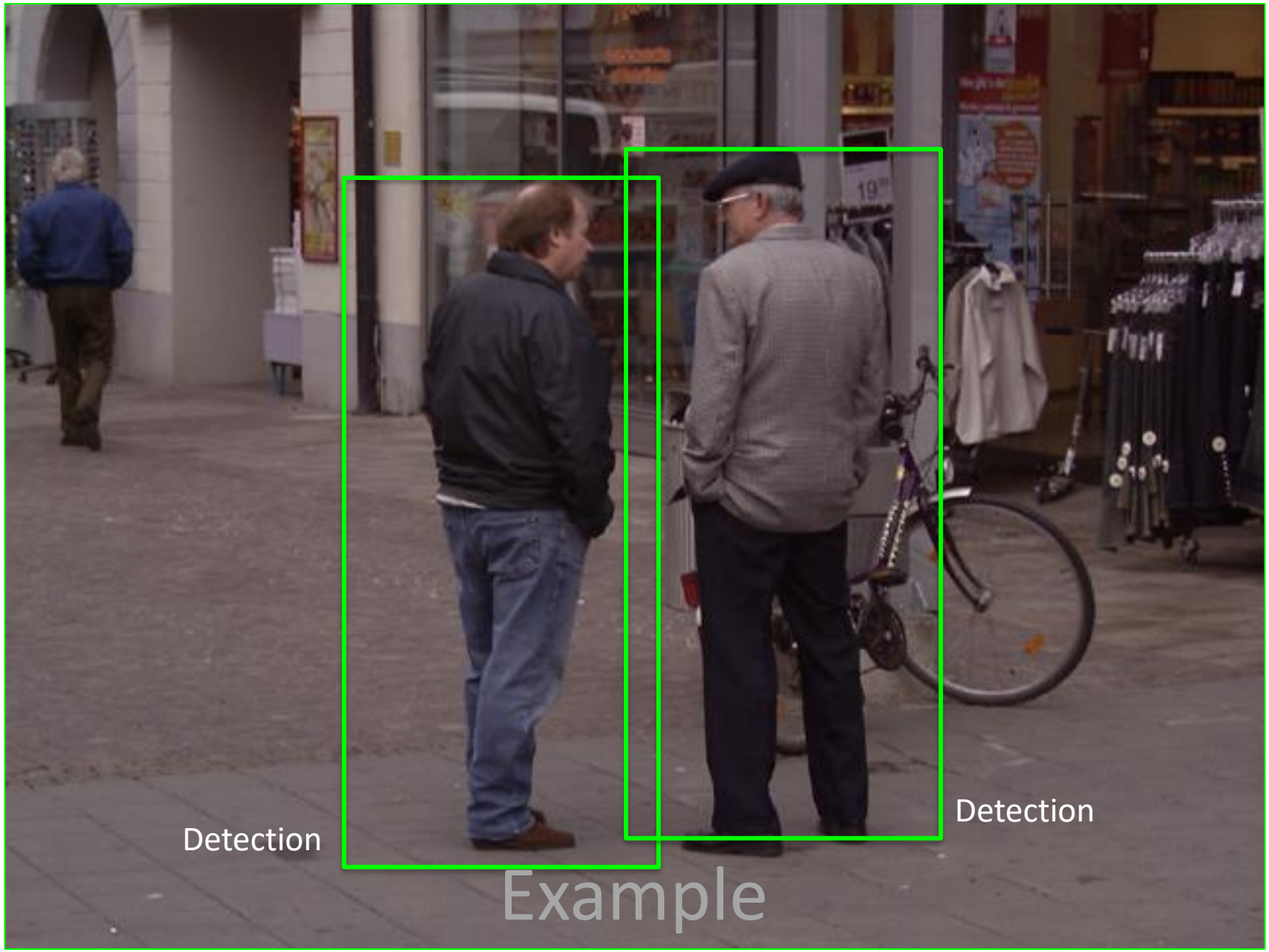

Example

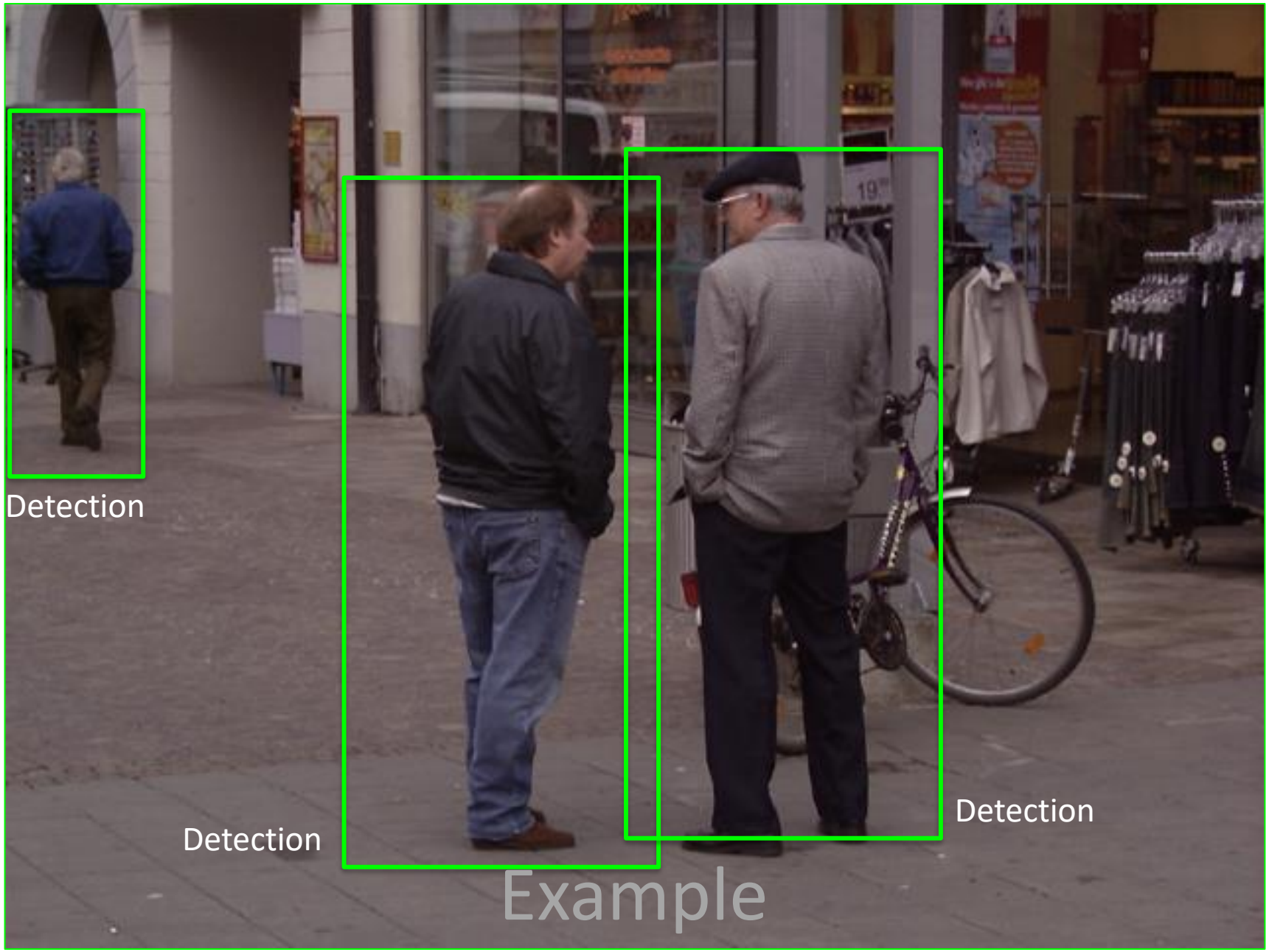

Example


Example


Detection
Example


Example


Detection
Detection
Example


Detection
Detection
Detection
Example